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The Solar Energy Transition

Implementation and Policy Implications

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10. The Solar Energy Transition as a Problem of Political Economy

The most important condition influencing the achievement of a solar transition is the selection of normative criteria by which the opportunities and risks of alternative energy futures are compared; yet the current manner in which a solar transition is evaluated frequently implies that these criteria are not open to choice or change. The result is an apparently irreconcilable dichotomy. On the one hand, solar advocates offer utopian visions of an entirely beneficent Solar Age that purportedly confirms solar's indisputable superiority over other energy options. We are encouraged to believe that once solar's intrinsic advantages are recognized, a transition to solar will implement itself. On the other hand, the very inertia of the existing political economy of energy sustains a belief that current arrangements for the production and distribution of energy constitute the only practical and, thereby, legitimate vantage point for assessing the opportunities and costs of a solar transition. This precludes evaluation of the adequacy for the future of the existing system, while ensuring that the costs of the current system's failures are taken as applicable to all possible alternatives. Consequently, solar energy is portrayed as a technology that in the near term can play at best only a supplemental role to conventional sources of energy supply.

Neither the prospect of a solar utopia nor the inertia of the existing political economy of energy provides an adequate basis for comparing the opportunities and risks of a solar transition to those of other possible energy futures. In our view, any energy transition embodies fundamental changes in the structure of relationships that undergirds energy production and use: changes in the distribution of risks and responsibilities between energy producers and consumers, in the alignment of political and economic power among competing energy interests, and in the institutional, legal

and policy framework that facilitates some energy options and inhibits others. From this perspective, the evaluation of energy futures is essentially a problem of political economy, and the paramount criteria for choosing an energy future are, or ought to be, the likely consequences for how, by whom, and in whose interests the political economy of energy will be governed. So viewed, both the risks and the opportunities of a solar future become clearer, as do the changes in political and economic relationships necessary to bring it about.

The Romance of Solar Energy

Critics have exploited a caricature of solar energy as an exotic fringe technology, but advocates have helped to create the conditions for such exploitation and have frequently contributed more than the critics to the mystification of solar energy. Advocates too frequently have portrayed the accomplishment of a solar transition as nothing less than the achievement of a virtuous society, the inevitable and only path to survival, the ultimate technofix. Such visions have contributed to the stigmatization of solar energy as a utopian technology, a science fiction solution to our energy problems or a conspicuous trademark of neo-primitivists who would lead society to a New Dark Age.[1] In all cases, the effect has been to impede serious evaluation of the opportunities and risks of a solar energy transition.

The mystification of solar energy is fostered by the dramatic claims of contemporary prophets who see modern civilization on the brink of a "New Age":

> The Fossil Fuel Age which began in the early 1700s in England will soon give way to an emerging Solar Age. Human societies will no longer be living on the earth's stored fossil fuel "capital" but its daily "income," i.e., solar-driven energy, either collected directly for thermal use, converted by solar cells into electricity or as wind and water power and bioconversion.[2]

The shift is expected to have significant ramifications throughout all spheres of society where, it is said, it will be accompanied by a profound and multidimensional transformation in the political, economic and social milieu. The

arrival of the Solar Age will signal the triumph of democracy, the accommodation to human scale, the achievement of local self-determination, the fulfillment of the virtues of material simplicity and personal self-reliance, and the emergence of a universal commitment to ecological harmony.[3] Some advocates go even further and proclaim that the solar transition signifies the fulfillment of "the ultimate moral imperative," symbolizing mankind's recognition and reverence for its fixed natural endowment and embodying a responsibility to preserve that endowment for future generations.[4]

Even more restrained advocates find it difficult to resist the romance of solar energy. Thus, for example, a recent AAAS volume intended to provide a comprehensive review of the state of solar energy developments in America and which warns that unforeseen problems could threaten the intrinsic advantages of solar energy, nonetheless begins:

> Solar energy is democratic. It falls on everyone and can be put to use by individuals and small groups of people. The public enthusiasm for solar is perhaps as much a reflection of its unusual accessibility as it is a vote for the environmental kindliness and inherent renewability of energy from the sun.[5]

Because solar energy is consistently portrayed as purely positive, adaptable to every occasion and offensive to no one, it is not surprising that some advocates conclude that a solar transition is irresistible. And indeed, Bruce Anderson, executive editor of Solar Age, has proclaimed that the recent change in national administrations and the more conservative political climate that now exists in Washington need be of little concern to advocates of solar energy:

> After all, solar has characteristics to satisfy nearly every political ideology and this discovery, albeit slow in coming, is producing a ground swell of bipartisan congressional action and local energy planning.[6]

Even in the absence of national political support, supposedly there is no justification for pessimism since the fortunes of solar really depend upon the "thousands of Americans who are 'getting their hands dirty' harnessing the sun" and who are going to "make solar happen" with or without such support.[7]

In 1977 Amory Lovins, perhaps the most outspoken advocate of soft energy paths, warned:

> We stand at a crossroads: without decisive action our options will slip away....Delay in widely deploying diverse soft technologies pushes them so far into the future that any credible fossil fuel bridge to there has been burned....[8]

More recently, however, Lovins has suggested that we should learn to enjoy the inevitable, rejoice in the "good news about energy" and perhaps conclude that the "energy problem is no longer very interesting" since "the conceptual outline of how to solve it is clear."[9]

But it is difficult to take comfort in a solar transition that remains fixed upon the horizon. Experience to date simply cannot justify confidence that intrinsic appeal combined with spontaneous action at the grass roots level will make a solar transition inevitable. The probable if unintentional consequence of adopting such a complacent attitude is the neglect of just those actions in the near term which are essential to achieve a solar transition.

The predisposition to circumvent or underplay the difficult choices and possible conflicts posed by a solar transition may be a conscious strategy of advocates that is intended to sustain a broad base of public support. Even so, the harm to solar's prospects would seem far greater than the possible benefits. Insofar as a transition is scarcely beyond the stage of germination, claims of solar's pragmatic inevitability only encourage perceptions of solar advocates as "salesmen of an energy Shangri-la"[10] who exhibit an arrogance comparable to the advocates of a nuclear technofix. More serious, by linking solar energy to supposedly universal social ideals, an image is fostered of an apolitical solar transition that is beyond the need for significant collective effort, thereby inviting endorsement without investment. Since affirmation carries no tangible obligation, public enthusiasm may become widespread, but it will remain shallow. The seemingly universal appeal of solar will likely evaporate as a solar transition is seen to require substantial behavioral and institutional changes. At the same time, active political support for a solar transition will be difficult to mobilize so long as it is presumed that there are only winners in a solar future.

Solar energy is not a technofix for the dilemmas of political choice. Langdon Winner may be correct that "a society based on energy conservation and decentralized technologies using renewable resources would, in all likelihood, look very much different from a society based upon massive deployment of nuclear reactors."[11] There can be no guarantee, however, that a solar society will be democratic. It is entirely possible to pursue options that ignore solar energy's versatility and adaptability to decentralized applications and instead seek to develop solar as a technofix for the current system of centralized production and distribution. More importantly, while technological choice is a constraint on the form of political life, it is not the principal determinant of its substance or ideals. Indeed, the critical relationship is in the other direction: the conditions of governance will in large part shape the criteria of technological choice and determine whether a Solar Age, or any of its expected social, economic and ecological benefits, can be achieved.

Solar Energy and the Myth of Market Omniscience

The expectation that a solar transition is inevitable frequently reflects an abiding faith not only in solar's technical superiority but also in its economic efficiency. Given the chance to compete openly in the marketplace, a solar energy transition is expected to implement itself: "economic realities guarantee that the world will move inevitably toward a Solar Age."[12] Some changes are seen as necessary if solar is to be given a fair, competitive chance: removal of artificial disincentives for solar adoption, particularly public subsidies of conventional fuels; modification in the pricing policies affecting all fuel types to reflect the marginal costs of additional production; and diffusion of reliable information on all energy alternatives so that consumers as well as producers can make sound economic decisions. It is undoubtedly true that without such changes solar will continue to be disadvantaged in the marketplace. It is quite a different matter, however, to expect that with the removal of market imperfections a solar transition is simply a matter of having solar options introduced, tested, certified, and diffused by market forces. What is most disconcerting about this expectation is the faith it reflects in the omniscience and intrinsic justice of the marketplace.

This belief in market omniscience places a solar energy transition in a double bind. If we assume that solar options will inevitably win out in the marketplace, we will direct our efforts primarily at making the marketplace work and avoid strategies for implementation that would interfere with market

forces. By this logic, we must also be prepared to accept that a "negative" market response to solar is a conclusive demonstration that a solar transition is not economically desirable and is therefore unjustifiable. Just what constitutes a reasonable market response is also at issue--skeptics and opponents insist that solar applications prove themselves by capturing a significant market share of supplied energy, perhaps 10-20 percent, but supporters frequently cite projective energy models which forecast, usually with beneficent state assistance assumed, a solar penetration of the energy supply market on the order of 20-40 percent in the unseen future![13] Neither group considers the manifest inadequacy of market share as a measure either of the nature or of the magnitude of change involved in any energy transition.

Few would argue, for example, that the advent of electricity as a widely available and applicable energy source stimulated basic social changes and was essential to commercial and technological revolutions in communications, science, and medicine. Yet electricity sales account for only about 9 percent of the energy consumed in the United States.[14] But if market share is a poor indicator of a successful energy transition, consider the case of a failed one. After massive federal subsidies, and despite a regulated price system which understates marginal costs and actually rewards overinvestment, nuclear power can claim only a 1.3 percent share of the end-use energy market.[15] In fact, firewood supplied more energy in 1980 than all civilian nuclear sources.[16] Nuclear energy's record is one of unparalleled construction cost overruns, a striking inability to survive economically without shifting perhaps the biggest cost of its own operations--the disposal of nuclear wastes--to the public, and the terrible legacy of environmental and biological dangers left to future generations. None of these, unfortunately, are directly measured by nuclear power's market share, and it would be preposterous to use such an index to evaluate the full extent of the failure of this much heralded energy transition. As these two quite different examples show, market share would appear to be unsuited to index either the advantages or the problems associated with a transition in energy use or production.

What is important to solar energy's future is whether we should constrain the achievement of a solar transition to the limits of what the marketplace allows. Many solar advocates are convinced that this constraint will not be serious and indeed that solar energy is the key not only to our energy future but to the vitality of the marketplace; that by the shift to renewable sources of energy "we can keep on producing without forcing the cost of production upward" and that this

will solve not only the energy crisis but the economic crisis as well.[17] Such expectations appear to reflect another version of a solar utopia, and if solar energy does not guarantee democracy, neither does it guarantee economic renewal. Barry Commoner may be right that "solar energy is emerging as a potentially creative force in the economy"[18], but it does not necessarily follow that the existing political economy will accommodate the forces of creativity. If, as Commoner argues, the source of the energy crisis is in a "private governance of the economic system" which benefits from the differential burdens created by rising costs of production[19] then there can be little reason to believe that by shaping our actions to accommodate "the market" the expected solar energy transition will ever materialize.

The Political Economy of a Solar Transition

A solar transition hinges upon whether our energy choices include solar alternatives as a systematic option. From this perspective the obstacles to a solar future lie principally in the political and economic constraints which currently make change inherently costly and serve to disadvantage if not exclude alternatives to conventional sources of energy supply. These constraints reflect structural conditions that have been reinforced over decades to sustain and enhance the existing energy system. They are manifest in the expected and seemingly natural roles and responsibilities fulfilled by energy producers and consumers, in the distribution and alignment of political resources in a manner favorable to the economics of conventional energy sources, in the operations of a financial and capital infrastructure that is geared primarily to serve a centralized system, and in the extensive body of law and public policy that has become both a source of legitimation and of incentives for current patterns of production and use. In the past, these conditions secured for western societies the benefits of a political economy based on cheap and available energy. Now, they have become primary sources of inertia in choosing an alternative energy future.

Overcoming the inertia of the current energy system will require more than simply correcting market imperfections, initiating government assistance to an infant solar industry, or allocating public resources to stimulate technological development and diffusion of solar options. A solar transition will require fundamental changes in political economy. The environment for energy choice, both in terms of markets and policies, will have to be expanded, and this expansion will necessitate actions which will destabilize current energy politics and economics.

Such fundamental changes in political economy typified the historic transitions to coal, oil, and electricity. In each case the energy transition involved more than a substitution in fuel types or the introduction of a supplement to existing fuels. Each transition was challenged by the institutional characteristics and expressions of the previous energy system, causing the political organization of allied economic interests. Each was confronted by legal and policy structures that secured the economic position and power of already prevailing energy sources and acted as barriers to new entrants. All of these transitions initially were evaluated on the basis of the costs and advantages for the existing energy system, and none of these transitions would have been achieved merely through the operations of supply and demand.

For example, the transition to coal in the mid-19th century involved more than a substitution for wood and other biomass products. It challenged an energy system primarily based on local public resources (forests) and replaced it with one based on regional commercial enterprises. The coal transition took place in the context of clear cost advantages for biomass products in certain energy uses (such as home heating) which emanated from government policy and law toward public lands, rather than intrinsic properties of woodburning. Similarly, the transition to oil beginning in the late 1800's in the U.S. displaced a regionally-based coal system heavily dependent upon public rail transport and introduced a system built on international production and consumption markets. While oil eventually surpassed not only coal but every American industry in both economic and political power, it originally confronted a competitor which received substantial public subsidy through the rail system, had successfully enlisted state and national governments to enforce low wages through anti-union and other labor policies, and could rely on a government laissez-faire philosophy to maintain the worst working conditions in American industry. To overcome such advantages, the oil industry required and received substantial government assistance in the organization of domestic and international markets and in the development of a transport structure to deliver its product cheaply. Finally, the electricity transition of the early 20th century represents perhaps one of the most spectacular instances of institutional change in American political and economic history. Joint government-industry actions necessary to create and sustain the electricity market included these radical departures from past norms and practices: monopolization of the market by region; creation of new and substantial electricity markets through rural electrification programs and hydroelectric projects, paid for with public funds; reorganization of responsibilities for capital risk so that private ventures in the

electricity market are publicly subsidized; and, with the advent of nuclear generation after World War II, the emergence of the American military as a major force in energy policymaking.

The changes in political economy which accompanied each of these transitions may well be overshadowed by those needed for a solar transition. Without changes in political economy, some solar options may be exploited but the principal opportunities offered by a solar future will be foregone. For the most part, solar's contributions would be limited to those which can be easily absorbed within a primary system of centralized energy production and distribution. Under these circumstances, the development of solar energy resources may actually be pursued in a manner which obstructs any energy transition. The approach adopted by federal government solar programs in the 1970's strongly suggests that this was the objective of national policy. Solar energy was portrayed as a potential long-term fuel substitute that might enable the existing energy system to withstand the decline of fossil-fuel resources with only marginal adjustments in its economic and institutional characteristics. Federal programs "overwhelmingly emphasized solar systems that could be plugged into the energy network as exact replacements of older systems that are taken out"[20] and that imitated the "design of conventional, centralized power sources."[21] As some observers concluded, this strategy appeared intended to assure that if a solar future materialized it would look remarkably familiar.

> Despite the diffuse nature of the resource, the research program has emphasized large central stations to produce solar electricity in some distant future and has largely ignored small solar devices for producing on-site power--an approach one critic describes as 'creating solar technologies in the image of nuclear power.' ...The massive engineering projects designed by aerospace companies which dominate much of the program seem to be intended for the existing utility industry--rather than individuals or communities--as the ultimate consumers of solar energy equipment.[22]

Distortion of solar energy's potential and implications is virtually inescapable so long as the criterion for judging energy futures remains the stability of the existing energy system. On this basis there is little reason to expect

materially different answers from those already given to the questions of energy choice. Thus, while solar energy may be an unlikely candidate to revitalize the utility industry, only in the context of such a prospect can a system of centralized energy production and distribution accommodate much less exploit an energy resource whose properties would otherwise dictate a focus on decentralized applications. As Amory Lovins has pointed out, we inevitably face a problem of exclusivity in choosing among energy futures that is not a result of "technical incompatibility of hardware but rather institutional and cultural incompatibility and logistical competitiveness of evolutionary paths..."; "the key distinction ... is in their architecture, the structure of the energy system".[23] Within the existing system one can envision a selected growth in end-use applications of solar as a supplement to conventional sources of supply. Fulfilling such a supplemental role, however, would hardly constitute a solar transition since the architecture of the energy system would remain unchanged. Indeed, limited solar applications might be seen as confirming the regenerative powers of the existing political economy of energy and thereby postponing the need for any alternative energy future.

Recognizing that structural changes are essential for a solar transition does not imply that technical problems are unimportant or that technological breakthroughs would have little impact on solar's prospects. However, even the technical dimensions of solar energy use need to be evaluated by the criteria of economic and institutional impact. Similarly, it is certainly possible that marketing techniques, better organization of the solar industry, wider industry-supported educational efforts, and other traditional and often successful strategies for improving market share could have an important influence on the fate of a solar energy industry. Yet, the effectiveness of these strategies is largely moot without basic changes in the organization of energy markets and in the orientation of public policies.

What changes in the political economy of energy are necessary to bring about a solar transition? While it is nearly impossible to predict social change of any kind, much less the specific social changes required for a so far nonexistent transition, nevertheless it is possible to identify the types of changes that are likely to accompany a solar future. One set represents necessary instrumentalities for expanded energy choice. These include changes in federal energy pricing policies, the removal of conventional fuel subsidies (or at least of the imbalance between conventional and alternative fuel subsidies), and the development of policies to offset entry barriers created by market imperfections. Such changes

would address problems that currently disadvantage virtually all competitors to conventional sources of supply. By themselves, however, these changes would do little more than equalize opportunities to substitute solar or any other alternative for conventional fuels. The possibility of a transition that would take full advantage of solar's environmental, economic, and political potential would remain slim, while the possibility that solar would be incorporated as a supplement to the existing energy system would be increased.

For a specifically solar transition to take place, other changes would be needed that bear directly on deriving the benefits of solar energy's distinctive resource characteristics. These relate to changes in the expectations, behavior, and responsibilities of producers and consumers and changes in the institutional infrastructure available to stimulate and support the choice of solar options.

Because solar energy is renewable and deliverable by decentralized technologies, the direct cost of its consumption rests not with the amount consumed, but with the size and sophistication of the system employed for its collection, transfer, and storage. Thus, capital rather than operating costs will determine its suitability at the retail/consumer level. This means a reversal of roles for most energy users: in the nonrenewable context most consumers purchased fuel, but in a solar-based energy system they would purchase the plant for delivery of the fuel. The behavioral changes required to accommodate this shift in responsibilities for capital costs constitutes an important challenge to the implementation of a solar transition. Households and other small energy consumers, for example, will have to reorient from a purchase-price to a life-cycle cost perspective in energy purchase decisions.

Without an accompanying change in the institutional setting within which consumers exercise economic choices, however, the redistribution of capital risks actually may leave consumers worse off. Thus, it will be necessary for financial institutions to advance capital funds for this new energy market and to alter radically their mix of loans both in size and maturity to meet an influx of comparatively small loan demanders. Similarly, since household energy choice is significantly linked to the characteristics of residential housing stock, the construction and building industries will have to incorporate the architecture and engineering of solar energy into their practices, and substantial changes will undoubtedly be required to capture the potential profits of energy-efficient building and subdivision design.[24] State and local governments will need to revise building codes and zoning laws to accommodate solar construction and retrofitting, and the

needed changes are likely to be substantial and controversial. Moreover, without a concurrent strengthening of the resources of these governmental units, the additional burdens created by the growing importance of their discretionary powers might simply overwhelm already beleaguered decision making and service capabilities.

As with earlier energy transitions, a solar future is likely to be accompanied by major shifts in political power that extend beyond the boundaries of energy production and use. As noted previously, the prospect most frequently anticipated by solar advocates is that decentralization in energy production and use would result in a general deconcentration of power and create a more participative community-based mode of decision-making. But decentralization will have this effect only if there is a concurrent enhancement of the opportunities for local citizen participation and a redistribution of authority and resources in the federal system to match the shift in risks and responsibilities to the local level. Similarly, a redesign in the prevailing structures of local governance may be necessary since decision-making at the local level has historically been no more responsive to broad based citizen participation than at the federal level. Obviously such changes are not confined to issues of energy choice and are neither benign nor neutral with respect to the current organization of political and economic power.

These changes would represent a significant deconcentration and redistribution of power and risk. They might have a profound and destabilizing impact on the political economy of energy. Yet, by themselves they create only the possibility of change to an energy future preferable to current arrangements. How, by whom, and in whose interest this new political economy of energy will be governed are influenced but unresolved by changes in infrastructure alone.

A pattern can be seen to emerge in the implications of social change associated with a solar future. Regardless of whether changes accompanying a transition are limited to the level of instrumentalities (such as balancing federal energy subsidies) or reach far beyond to affect the institutional structure in our society, an upheaval of substantial dimensions in the political economy of energy seems unavoidable. Yet, it is equally apparent that such fundamental change need not result in a preferred social future. Conflict is inherent in all transitions in political economy; the benefits or risks of transition can only be gauged by the nature of the resolution achieved to these conflicts.

The conflicts that might accompany a solar transition are by no means limited to issues of political and economic scale. If unshaded and unobstructed space becomes a widely sought economic good as a result of increased use of solar technologies, solar interests will confront some of the most powerful forces in urban industrial society. This confrontation could have enormous and not necessarily desirable implications. One possibility is that this conflict would encourage greater social planning of technology. But historical experience painfully demonstrates both the resistance of such social confrontations to resolution through planning efforts and the failure of planning to ensure public control of technology. Indeed, if the past is any guide, a solar transition could result in the creation of a new property interest and the resurgence of an economic class based on land ownership that would govern the new energy system. Such conflicts and their prospective resolutions may seem unlikely, but they are no more dramatic than those which accompanied earlier energy transitions.

Fundamentally, political and economic structures represent systems of social valuation in which the worth of social actions and goals are determined. In the contemporary case, energy alternatives including solar are unfailingly compared in both economic and political terms with the performance of the existing system of energy. Such a comparison makes sense only if and so long as the present political economy of energy is afforded the role of social measure. If, however, it can be shown that the current political economy is unstable and no longer viable, then it makes little sense to depend upon it as a system of energy valuation. This is of course precisely the issue raised by a solar transition. Are we to rely on existing political and economic structures to determine our energy future and solar's role in that future, or must the basis of social valuation itself change before our energy future can be decided? Because the very basis of valuation is at stake in a solar energy transition, conflict is inescapable between those interests dependent upon the existing political and economic order to establish their superiority and those which depend upon the failure of the existing order to define theirs.

Understood as a problem in political economy it becomes clear that a solar transition will not take place simply by the force of recognition of solar energy's social, environmental, or economic benefits. This is not because these benefits cannot be shown to be real or ample. Rather, the underlying dilemma is that realizing such benefits will require substantial changes that can only be seen as immense costs from the

vantage point of the current energy system. These changes will alter not simply the form and appearance of the political economy of energy but the structure of social valuation that drives it.

Dynamic Conservatism and the Challenge to a Solar Transition

Recognizing the inertia of the existing energy system should direct the attention of solar advocates to the problem of "dynamic conservatism": the predisposition of political and economic institutions to regard change as a threat to the stable state (rather than a product of its failures) and to fight to remain the same.[25] The dynamic conservation of the existing political economy of energy represents a natural expression of resistance to changes which unquestionably challenge not only the technology and structure of established institutions but, perhaps more importantly, the theory and ideology which supports and justifies them.[26] This means that the prospect of a solar transition is constantly at risk of being dismissed as an abstraction while at the same time, the energy status quo, however unstable it may be, is accorded the aura of stability. As Donald Schon has pointed out:

> The most prevalent responses to the loss of the stable state are anti-responses. They do not confront the challenge directly. They seek instead to deny it, to escape it or to become oblivious to it....When processes embodying threat cannot be repelled, ignored, contained or transformed, social systems tend to respond by change--but by the least change capable of neutralizing or meeting the intrusive process.'Least'...in terms of how little or how much must be given up in order to accommodate them.[27]

In the current environment there are at least three strategies of dynamic conservatism that challenge the prospect of a solar transition: denial, containment and crisis control. Each reflects a different view of the extent to which change is seen as necessary on the one hand and threatening on the other. In all cases, however, it is assumed that we can and ought to conceive of the limits of a solar energy transition from the vantage point of the stable state. So viewed, the advantages of a solar future are regarded as ephemeral, while the costs appear substantial. Each of these forms of dynamic conservatism operates through a strategy of charging the costs

of change to solar alternatives, while avoiding any systematic evaluation of the costs of remaining the same.

The Strategy of Denial

Under the first strategy the requirement for change in the current system is denied, since the energy problem is portrayed as external to the system: in the machinations of the oil cartel or in the misguided exercise of public authority that controls prices, regulates investment and profits, and generally sustains disincentives for development and production. The solution is seen to lie in the defense of the system against challenges to its stability while the search goes on to discover and implement the conditions of system renewal that can restore an era of cheap energy.

From this perspective a solar transition or any energy transition engenders massive costs of solving the wrong problem, since the existing energy system is not in need of replacement. Moreover, the pursuit of a solar future would be seen as carrying additional costs, since it would not alleviate and perhaps would worsen many energy-related problems that the current system actually created. Thus, it might be pointed out that a solar transition will not assure a return to an era of cheap energy, nor will it provide an antidote to declining economic productivity and growth. It also will not remove the pain of reorganizing society around more energy-efficient spatial patterns while the implementation of alternatives proceeds. While reliance on solar energy may not add to environmental deterioration, it will not by itself remove the danger and a solar future certainly need not represent a cure for America's resource wastefulness and profligacy. In addition, a solar transition may actually contribute to chronic economic and social problems. Thus, for example, efforts to displace the use of fossil fuels with solar sources may intensify the need for and use of land--either to collect and store energy or as an essential adjunct in providing unobstructive and unshaded spaces--for certain solar technologies. If so, a solar future would strengthen a primary source of inflationary pressure in residential and commercial construction markets and add to the speculative demand for housing to the extent that solar-heated buildings become an attractive hedge against energy price inflation.[28]

Clearly, these costs are due to chronic weaknesses in the existing energy system and have little to do with progress toward a solar future. The burden of such costs, however, is likely to be attributed to a solar (or any) transition so long as the existing energy system can succeed in denying its past

and present failures and its growing instability. If the strategy of denial is successful, attention will be deflected from the high risks of continuing with the status quo, while at the same time a prohibitive premium will be placed on change towards any alternative energy future. Accommodating this strategy of dynamic conservation effectively would limit solar alternatives to providing quick fixes for current energy problems and shoring up the existing system. The possibility of choosing an alternative energy future would be foregone in favor of an expected return to the stable state.

The Strategy of Containment

In the second strategy the need for change is conceded because the existing system is seen to reflect a number of weaknesses that are not self-correcting. The problem is to stimulate the system's change through a process of technological evolution and innovation. Removing the obstacles to such technological change, however, will create transition costs.

Under this strategy, the pace and extent of a solar transition would be contained by charging these costs against solar options rather than expecting them to be absorbed by the existing system as a price for its failures. Thus, for example, research and development on new solar technologies displaces capital that might otherwise be used to preserve existing markets or enhance current technologies. To avoid the deleterious effects of such displacement to established energy industries, public expenditures will be expected. Similarly, the cost of removing market imperfections that impede the introduction of new solar alternatives will be portrayed as the natural costs of market entry and considered the responsibility of the solar industry. For example, uncertainty about the success of new solar technologies is likely to be greater than that for alternatives already available. Established energy interests will portray this uncertainty as a source of risk and will therefore apply the purportedly natural requirement of above-normal returns before investing in such ventures unless additional government incentives were provided. Further, the fact that little or no information may be available either to prospective purchasers or suppliers about solar options and that a solar industry would have to commit a high proportion of its resources to altering conditions of widespread ignorance and misinformation would be represented as the justifiable expense of a new enterprise. Since virtually any action in a complex society will have unintended side effects, the costs of transition will also extend to coping with currently unforeseen consequences of a solar transition. To the extent that such side effects might be negative, pro-

ducers and buyers could defer decisions about solar while they await a clearer picture of the real costs of these technologies. On the other hand, advantageous side effects might also trigger underinvestment by consumers and suppliers until ways are found for them to capture such benefits and thereby reduce what are termed "transactions" costs. In either case, the ability of solar options to compete with existing technologies will be hampered unless certain public expenditures are made to offset the unavoidable natural problems of introducing and diffusing technological innovations. Finally, to the extent that the costs of transition are met by government expenditures, established industries may expect to be compensated for losses induced by such spending.

Considered as "realistic" reflections of problems of change in an imperfect world, these costs may appear to be the necessary and reasonable burdens of a solar transition. In fact, recognizing such burdens might be portrayed as serving a useful social purpose, since it discourages frivolous and destructive changes, insures that only those technologies which represent the best uses of society's resources and labor will be developed, and limits the extent of such development to the constraint of economic optimality. There are interesting questions, of course, as to how such precision can be adduced from patently imprecise conditions of ignorance and why market-like solutions should be sought in areas where market failure is inherent. The more central question, however, is why such costs should be assigned to a solar transition when they were created by the instability of the existing political economy of energy and its inability to assure future affordable energy supplies. Far from burdens brought on by solar's competition with fossil fuels, these factors of uncertainty and market unreliability actually reflect the structural inflexibility of the existing system when confronted with the need for change.

Insofar as these transition costs will be attributed to and charged against solar alternatives, progress toward a solar-based energy system will be highly contained. Those technological applications most compatible with present methods of generation or delivery will be favored, since they will involve fewer and lower potential risks and will minimize the problems of commercialization and diffusion. Clearly, a solar transition circumvented by such costs of change will not displace the existing institutional structure as the primary influence on our energy future. Energy choices would continue to be so dominated by the limits of the current political economy that differences between a pre- and post-solar society would be less striking than their considerable similarities.

The Strategy of Crisis Control

The strategy of crisis control represents an extension of the strategy of containment, but in this case it is recognized that structural weaknesses of the existing system are too severe to await rectification through an orderly process of technological renewal. Change is seen as being accompanied by a breakdown in various sectors of the energy system that may result in massive disruptions of crisis proportions unless they are planned for and controlled. While it is acknowledged that the existing system may be or will become obsolete, its behavioral and institutional structure purportedly cannot be abandoned without unacceptable social costs. Therefore, a solar transition will be expected to internalize responsibility for these social costs and, hence, proceed in a manner which minimizes disruptive consequences.

As an example of a source of disruptive change, some energy analysts have argued that we face a neo-Malthusian dilemma with fossil fuels in that even their moderate or reduced use triggers explosive rates of environmental degradation that far outstrip any technological capacity to contain, much less correct, the damage. Because of this, the rate of reduction and eventual prohibition of their use may have to be determined by biological and ecological rather than economic criteria and therefore could result in major discontinuities in energy supply.[29] Another source of disruptive change is seen in the vulnerability of power utilities. Here the concern is that while utilities represent an important bridge between nonrenewable and renewable energy futures, they could be made largely obsolete by this passage. Because utilities control a substantial share of the capital available to the energy system and maintain an essential part of the energy distribution subsystem, early obsolescence could seriously undermine the prospects for an energy transition, especially one based upon renewable resources. A solar future, however, is likely to speed the collapse of these utilities, which are already experiencing serious fiscal decline. The social costs of this collapse will be enormous, and while certainly not caused by the transition to a new energy future, it purportedly would be irresponsible to neglect planning for them as part of a solar transition.

It is significant that this strategy of dynamic conservatism does not rely upon a logic of cause but one of consequence. Cost assignment focuses on the realities of change as they unfold, and thus no claims are made that the source of these costs lies in a solar transition. An important issue remains as to whether such costs should--or will--constitute limits on the progress and shape of a solar future. Does the

precarious future of power companies and the disruptive potential of their collapse justify actions to encumber certain solar options simply in the interest of forestalling such disruption? Similarly, the environmental danger of continued fossil fuel use cannot be ignored, but does that mean that solar development should be oriented to accommodate those energy uses that could be interrupted because of a ban on fossil fuels? Redirecting the focus of solar development solely to address these problems may result in a serious compromise of solar-based possibilities. To the extent that solar's potential is mortgaged to prevent, reduce, pay for, or control the costs of disruption, the likelihood increases that much of the institutional architecture of the current energy system will be retained and that real choice about energy futures will remain illusory.

The logic and expectations underlying these three strategies and the costs they project derive from the dynamic conservatism of the current political economy of energy. If these strategies are accommodated, there will be no solar transition or only a very modest one. The challenge to advocates of a solar or any other energy transition is to establish a basis for evaluating energy futures that subjects the energy status quo to the same order of accountability as is required of its alternatives.

Evaluating a Solar Transition

The emerging national policy environment of the 1980s provides ample evidence of the challenge to a solar energy transition. The 1983 budget proposals of the Reagan Administration call for eliminating virtually all federal support for solar research while doubling funding for breeder reactor research.[30] These proposals reflect the related beliefs that current arrangements for the production and distribution of energy remain the only practical ones and that solar energy should be consigned to the status of a futuristic technology. The social cost of maintaining these beliefs is the double bind of being committed to a system that does not perform effectively even on its own criteria and has not generated any alternatives.

In our view the failures of the existing system are fundamentally failures of governance. They cannot be repaired by technological or economic renewal, by decontrol of energy prices, or by diffusing an external cartel's control of oil supplies. The energy crisis represents a breakdown in a political and economic system of energy production and use that could sustain itself only so long as it provided cheap and

readily available energy. The system is currently preserved by the belief in a possible return to such an era. Indeed, the prospect of a solar transition sometimes has contributed to that belief and has served to perpetuate an expectation that the existing system can survive in a modified but not radically different form.

What ought to have been learned from recent experience is the futility of trying to rescue the existing political economy of energy. Striking evidence of this futility is that since the 1973 embargo, the major contributions to meeting new energy needs have come through efforts at conservation and other decentralized activities outside of what is supposedly the primary energy system. Yet, nearly all government investment has been in efforts to restore the viability of centralized energy production and distribution.

The questions that should be addressed in evaluating an energy transition are:

- What are the conditions of political economy necessary to bring it about?
- Would the transition enhance or complicate collective control of technology?
- Who bears the risks and who has access to the opportunities created by such an energy transition?
- Would it extend the capacity for individual and collective choice of energy futures?

In general, what are the implications for the governance of our energy future?

If we learned from experience, we should conclude that the major opportunities for improving the governance of our energy future lie in an increasing reliance on decentralized systems of supply and choice. The importance of decentralized efforts that rely on behavioral and institutional as well as technological adaptations lies in their potential for stimulating a transition toward a new system of expanded energy choice. The existing system, however, defines these decentralized adaptations as only temporary adjustments along the path of system renewal. That is all they can be unless the current constraints on energy choice are removed.

While a solar transition will not guarantee a preferred system for the governance of our energy future, it can offer opportunities different from those which currently exist. Many of these opportunities are well recognized: a generally less environmentally destructive mode of energy production and use than currently exists; assured stability of and access to supply; and the strong likelihood that if solar applications are decentralized and varied, they will enhance capacities to adapt and control energy technologies to satisfy changing social needs. But the issue is not only the opportunities which could be created by such a transition; it is also who might have access to them. To the extent that a solar transition would foster a decentralization of energy production and distribution, it could afford the possibility of greater opportunities for participation by individuals and communities in shaping the patterns and characteristics of energy use. Moreover, a larger number of energy choices might be available to individual users than at present. In this sense, a solar transition might create a broader distribution of advantages than the current system. While a growing reliance on decentralized solar technologies would not eliminate economic and political risks, it would create the real possibility for continued choice among energy futures. In contrast to fossil and nuclear futures, a solar future does not require massive investment in a centralized infrastructure that cannot be abandoned should it become obsolete. If a solar transition were to reflect a dependence on a variety of diffuse technologies, the structural costs and risks of future adjustments might not dominate energy choice to the degree that they do at present.

We believe that the creation and maintenance of conditions for collective choice are essential for the governance of our energy future. Current policy denies the need for collective choice of energy futures, and current arrangements are seen as providing the only normatively acceptable criteria for assessing our energy condition and prospects. In place of new opportunities we are still being asked to place confidence in the regenerative powers of technology and the "free" market and to feel assured, as the Secretary of Energy has recently put it, that the way to solve the nation's energy problems is to "produce, produce, produce."[31] In light of the energy history of the last decade, such utopian faith in production, technology and markets can only be regarded as mystical. It hardly constitutes a viable substitute for active collective efforts to govern our energy future.

References and Notes

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2. Hazel Henderson, "Thinking Globally - Acting Locally: Ethics for the Solar Age, " Alternative Futures, Volume 4, No. 1, Winter, 1981, p. 100. See also Hazel Henderson, The Politics of the Solar Age: Alternatives to Economics (New York: Anchor/Doubleday, 1981).

3. These political, economic and social characteristics of the New Solar Age are variously described in Joseph A. Camilleri, Civilization in Crisis: Human Prospects in a Changing World (Cambridge: Cambridge University Press, 1976); Victor Ferkiss, The Future of Technological Civilization (New York: Braziller, 1974); Mark Satin, Now Age Politics: Healing Self and Society (New York: Delta, 1978); Kirkpatrick Sale, Human Scale (New York: Coward, McCann and Geoghegan, 1980); Jeremy Rifkin, Entropy: A New World View, (New York: Viking Press, 1980); and Henderson, Ibid.

4. Jeremy Rifkin, Ibid, pp. 259-260.

5. William D. Metz and Allen L. Hammond, Solar Energy in America (Washington D.C.: American Association for the Advancement of Science, 1978) p. 1.

6. Bruce Anderson, "Editor's Note: Making America Great Again," Solar Age, vol. 6, No. 1, January, 1981, p. 5.

7. Ibid.

8. Amory B. Lovins, Soft Energy Paths: Toward a Durable Peace, (New York: Harper and Row, 1977) p. 59.

9. Amory Lovins and Hunter Sheldon Lovins, "Good News About Energy" New Age, October 1980, p. 30.

10. Bertram Wolfe, "G E Executive Dubs Soft Path a 'Shangri-La'" in The Energy Controversy, op. cit. p. 168-181.

11. Langdon Winner, "The Political Philosophy of Alternative Technology," Technology in society, vol. 1, Number 1, Spring 1979, p. 77.

12. Jeremy Rifkin, op. cit., p. 196.

13. Typical projections of solar's market share by the year 2000 are on the order of 20-25 percent. CF. DOMESTIC POLICY REVIEW OF SOLAR ENERGY, A RESPONSE MEMORANDUM TO THE PRESIDENT OF THE UNITED STATES (Washington D.C.: National Technical Information Service, February 1979). More optimistic forecasts have ranged up to 40 percent; while solar's critics doubt that any significant penetration will take place (e.g., the editor of World Oil characterized solar's future share as "a mosquito bite on an elephant's fanny"). See Robert Stoubaugh and Daniel Yergin, eds., Energy Future; Report of the Energy Project at the Harvard Business School (New York: Ballantine Books, 1979), p. 231.

14. Based on 1979 consumption data from U.S. Department of Energy, State Energy Data Report: Statistical and Technical Documentation, 1960 through 1979 (Washington, D.C.: Government Printing Office, September 1981), p. 4.

15. Derived from 1979 consumption and end-use data, ibid. The 1.3 percent share was calculated as follows:

$$\text{nuclear energy end-use share} = \frac{\text{nuclear energy consumption} \cdot \text{total electricity sales / energy input at electric utilities}}{\text{total energy consumed} - \text{electrical energy losses}}$$

This calculation is based on the assumption that nuclear generating plants operate at the same rate of efficiency, taking into account plant shutdowns and idleness, as the electric utility industry average.

16. Joe Guerra, "Nukes Face the Bottom Line," in Working Papers, Vol, 8, no. 6 (November/December 1981), p. 20.

17. Barry Commoner, The Politics of Energy (New York: Alfred A. Knopf, 1979) p. 32.

18. Ibid., p. 33.

19. Ibid., p. 75.

20. Metz and Hammond, op. cit., p. xiii.

21. Barry Commoner, op. cit., p. 44.

22. Metz and Hammond, op. cit., p. 1.

23. Amory Lovins, The Energy Controversy, p. 42 and 29.

24. The importance of the construction industry in current energy decision making is substantial. As Colin Norman in a recent Science article observed, "more than half of the household appliances sold in the United States are bought by developers and landlords rather than by those who will use them and pay the fuel bills." See Colin Norman, "Reagan's Energy Policy and Other 'Myths'", in Science vol. 213 (September 26, 1981), p. 1401.

25. The concept of dynamic conservation is discussed in Donald A. Schon, Beyond the Stable State (New York: W. W. Norton and Company, 1971). See especially pp. 31-60.

26. Ibid., p. 19.

27. Ibid., p. 29, and pp. 49-50.

28. For example, statistics from the National Association of Home Builders indicate that land accounted for 23 percent of the cost of new single family housing in 1980 compared with 11 percent in 1949. On the other hand, labor and materials costs as a percent of housing cost actually declined during this same period, profit and overhead increased only slightly, and financing rose from 5 percent to 12 percent.

29. See Chapter 1, "Environmental Benefits of a Solar World" by Denis Hayes and Chapter 2, "Planning the Solar Transition" by James MacKenzie.

30. See "Research Fares Well, but Aid for Students is Cut," New York Times, February 7, 1982, sec. 1, p. 30; and "Fiscal Reforms: A Blueprint for Ideology," Philadelphia Inquirer, February 7, 1982, sec. 6, p. 4-F. In addition, President Reagan has asked Congress to rescind 1982 funding for the Solar Energy-Conservation Bank (see Federal Register, Vol. 47, no. 28 (February 10, 1982), p. 6218.

31. Secretary of Energy James B. Edwards quoted in "Energy Conservation: Spawning a Billion-Dollar Business" Business Week (April 6, 1981), p. 69.